NUCLEAR ENERGY UNIVERSITY PROGRAMS

Verification & Validation of High-Order Short-Characteristics-Based Deterministic Transport Methodology on Unstructured Grids

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Project Number: 09-366

Initiative/Campaign: Gen IV/Methods

Abstract

The research team has developed a practical, high-order, discrete-ordinates, short characteristics neutron transport code for three-dimensional configurations represented on unstructured tetrahedral grids that can be used for realistic reactor physics applications at both the assembly and core levels. This project will perform a comprehensive verification and validation of this new computational tool against both a continuous-energy Monte Carlo simulation (e.g. MCNP) and experimentally measured data, an essential prerequisite for its deployment in reactor core modeling. Verification is divided into three phases.

The team will first conduct spatial mesh and expansion order refinement studies to monitor convergence of the numerical solution to reference solutions. This is quantified by convergence rates that are based on integral error norms computed from the cell-by-cell difference between the code's numerical solution and its reference counterpart. The latter is either analytic or very fine-mesh numerical solutions from independent computational tools. For the second phase, the team will create a suite of code-independent benchmark configurations to enable testing the theoretical order of accuracy of any particular discretization of the discrete ordinates approximation of the transport equation. For each tested case (i.e. mesh and spatial approximation order), researchers will execute the code and compare the resulting numerical solution to the exact solution on a per cell basis to determine the distribution of the numerical error. The final activity comprises a comparison to continuous-energy Monte Carlo solutions for zero-power critical configuration measurements at Idaho National Laboratory's Advanced Test Reactor (ATR). Results of this comparison will allow the investigators to distinguish between modeling errors and the above-listed discretization errors introduced by the deterministic method, and to separate the sources of uncertainty.